374
E5

VOL. I. NO. 1.

JOURNAL

OF

THE ENGINEERING SOCIETY

OF

THE LEHIGH UNIVERSITY.

JUNE, 1885.

ENGINEERING SOCIETY JOURNAL.

Subscription, Fifty Cents per year. Single Copies, Fifteen Cents.

EDITORS FOR THE SOCIETY:

F. FREYHOLD, '85.
I. A. HEIKES, '85.
C. M. TOLMAN, '85.

CONTENTS:

IMPROVEMENT IN DRAFT OF CYLINDRICAL BOILERS.. 1
A DEVICE FOR ARRESTING CARS AND LOCOMOTIVES..... 2
PERPETUAL MOTION..... 4
THE INJECTOR..... 6
THE BETHLEHEM WATER WORKS. 11
THE COMPOUND BLOWING ENGINE AT THE BETHLEHEM IRON COMPANY'S WORKS..... 13
THE PAYNE HIGH SPEED ENGINE IN THE ELECTRICAL LABORATORY... 15
THE ELECTRIC LIGHT IN BETHLEHEM..... 18
THE UNIVERSITY PARK..... 19
THE LABORATORY..... 20
OBITUARY 25
EDITORIAL 26
BOOK NOTES 27
ALUMNI NOTES..... 27

THE COMENIUS PRESS,
BETHLEHEM, PA

135435

JOURNAL

OF

THE ENGINEERING SOCIETY

OF

THE LEHIGH UNIVERSITY.

VOL. I. JUNE, 1885. No. 1.

IMPROVEMENT IN DRAFT OF CYLINDRICAL BOILERS.

The general practice among steam-users is to introduce the cold air under the grate bars, where it comes in contact with the live coals, becomes heated, and takes its natural course to the stack. It appears then that a portion of the fuel is consumed in raising the temperature of the entering cold air. To remedy this the following plan has recently been adopted with success at three of our boiler houses.[1]

A cylindrical casing, generally of brick, envelops the stack at a distance of 10 to 12 inches, rising to a height of 3 to 5 feet. This envelope connects with a brick flue built on top of the main flue leading to the stack. This top flue separates at the back of the boilers into two flues which lie on each side of a nest. These side flues are so constructed at the front end of the boilers as to have numerous openings leading directly under the grate bars. It will then be seen that the cold air enters the casing and travels in a flue which is directly on top of the main flue containing the heated air and gases passing to the stack, and that consequently by the time this cold air reaches the grate bars, it has acquired considerable heat, and if the fire doors are properly closed, a strong continuous draft is produced.

[1] Beaver Brook Estate, Audenried, Pa.

The results of my investigation are as follows: By measurement with an anemometer I determined the natural draft under a set of boilers at the entrance to the chimney as 200 cubic feet per minute. With the addition of the hot air flue as described above —and without the use of the steam blower—a draft of 600 cubic feet per minute was obtained. The temperature of the air in the hot air flues as it enters under the grate bars was found to be 190° Fahr.

In regard to the saving of fuel, the following results were obtained: In the nest of boilers under observation 7400 pounds of pea coal were consumed in 24 hours without the hot air flue. With the use of the hot air flue only 4900 pounds of pea coal were used in the same time, and produced the same amount of steam.

The average cost of adding the hot air flue to a nest of boilers is $60, at the present rate of wages.

It is thus seen that a saving of 360 tons of coal is annually effected by introducing the hot air flue. As the average cost of mining and preparing a ton of coal is $1.28, an actual saving of $470.80 is made at the mines; and the improvement pays for itself in less than two months.

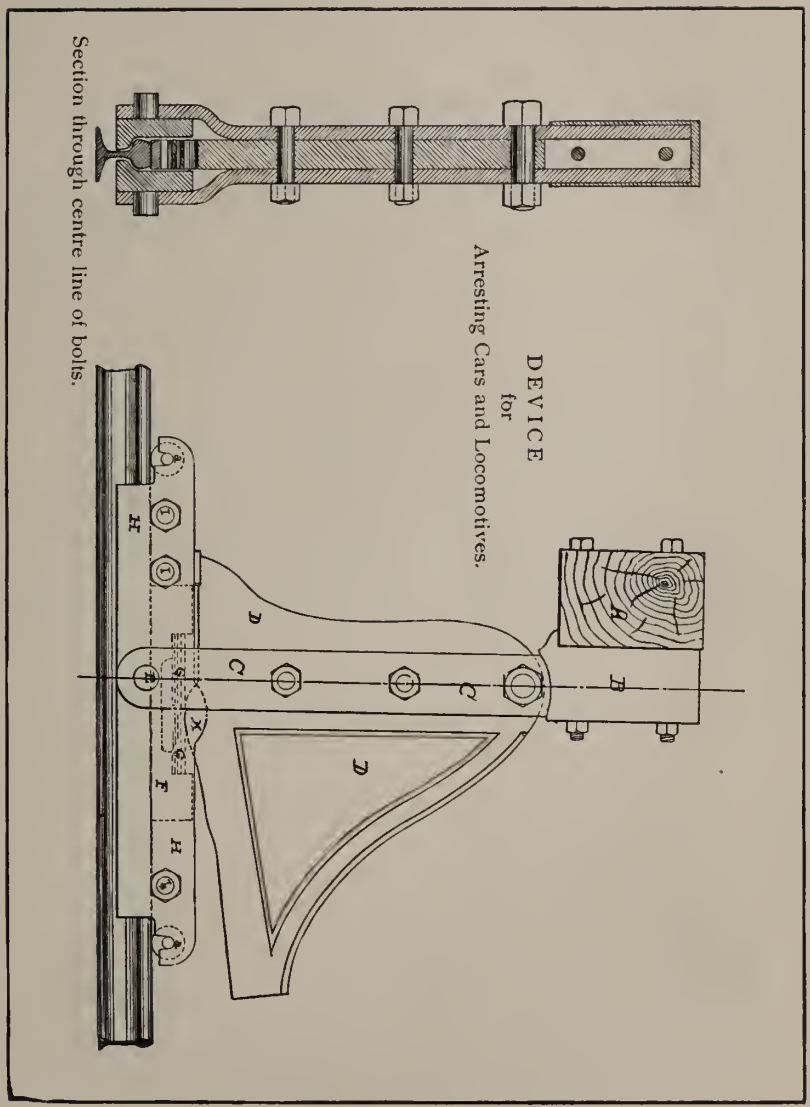
In manufacturing districts which are more or less distant from the mines, and where the price of coal is from 300 to 400 per cent. higher than that quoted above, the economy of introducing the hot air flue becomes more apparent.

ELMER H. LAWALL, C. E.

A DEVICE FOR ARRESTING CARS AND LOCOMOTIVES.

The accompanying sketch shows a device invented and patented by M. F. Bonzano of Philadelphia for gently arresting a car or locomotive as it approaches the terminus of a track, to take the place of the cumbrous fixed bumper now in use.

Referring to the sketch, the device consists of two parts similar to the one shown, connected together by angle iron braces. The cross-beam *A* is the part which comes in contact with the buffer


DEVICE
for
Arresting Cars and Locomotives.
Section through centre line of bolts.
A
B
C
D
F
H
K

of the cars. The cross-beam *A* is bolted to the cast iron boxes *B*, which fit on the ends of the wrought iron braces *C*. These braces *C* are in turn bolted rigidly to the castings *D* and the whole is pivoted at *E*.

F is a cast iron shoe which rests on the rail and is hollowed out in its length to hold the steel spring plates *G*, shown in dotted lines, upon which the casting *D* rests at the point *K*.

Part *H* is a casting made to fit loosely the head of the rail underneath. It moves along the rail by means of the rollers *a-a*. It is made in two parts which are held together by the bolts *I*.

The action of the device is as follows: When the buffer of the car strikes the cross-beam *A*, the whole arrangement will yield and slide along the rail, but at the same time the casting *D* will be pressed upon the spring *G*, and this pressure is in turn communicated to the track by means of the shoe *F* with sufficient force to gently arrest the train; *i. e.*, the momentum of the car or cars will be absorbed in the friction of the shoe on the rail, and the damaging shock which the train receives from the stationary bumper will be avoided. The amount of friction between the cast iron shoe *F* and the rail is regulated by the stiffness of the plate springs *G*. The stiffer the springs, the greater the friction, and the more rapidly the train can be stopped. In experiments with this bumper very satisfactory results were obtained. A small freight train moving at the rate of twelve miles per hour was brought to rest in a distance of fourteen feet.

THOS. NICHOLSON, JR., M. E.

PERPETUAL MOTION.

In these days it is only the very conceited or very ignorant inventor who has the courage to acknowledge himself to be in search of perpetual motion. As a question of science it ceased to be of any interest when the law of conservation of energy became established. To the man of science there is nothing clearer than the fact that no system of mechanism can be made to turn out more energy than is put into it, and in order to keep its wheels in motion a constant supply of such energy must be furnished from an outside source. In short, the only possible

service which a combination of mechanical powers can accomplish is in transforming the energy put into it, so as to make it available for use. In such transformation there is always loss instead of gain.

It is, no doubt, possible for an inventor to construct a machine of such complication as to make it a problem of considerable difficulty to analyze its working and point out in detail the exact points where the fallacy appears, but since, as a whole, a perpetual motion machine violates the principles above referred to, such an analysis is in any case useless. The principle of conservation of energy is as firmly established as the law of gravity, or the Copernican system, and when a device for any purpose is supposed to act in contradiction to it, this at once shows a fallacy to be involved.

It is not an uncommon thing to find mechanics or others, whose scientific education is not extensive, puzzling their brains over supposed discoveries, the true character of which they do not themselves see, or will not acknowledge. A somewhat common example of this is a device which it is supposed will multiply the efficiency of a motor. The inventor disclaims all idea of perpetual motion, knowing this to be an impossibility, but believes that by some means he can make one horse power do the work of ten. It is, of course, only a variation of the problem of perpetual motion.

Considerable time and money have been wasted on another class of devices in which the violation of the above law is less obvious. It is clear to all that there is a vast amount of energy lying about us on every hand, which might be made to turn all the machinery of the world if we could only utilize it. The principle of transformation of energies opens up a vista of almost infinite possibilities. If we can only get hold of any kind of energy in a tangible form, whether that of heat, electricity, or mechanical motion, we can transport it to any distance, and convert it into any form required for use in the service of man.

Now, the earth itself, and everything with which we are brought in contact, contains a vast amount of energy in the form of heat. Why should this not be pressed into service and made to perform useful work, in turning machinery, lighting streets and houses, heating furnaces and buildings? If the energy contained in this form, even in an iceberg or a glacier, could be made use of, a great amount of work could be performed by its agency. As

this is supposed to imply nothing which is at variance with the law of conservation of energies, it has proved quite fascinating to inventors and to theorists. There is as great a difficulty here as in the problem of perpetual motion, however, and one no less elementary. The forces or energies, or whatever we see fit to call them, which we see in the world around us, are in a condition of static equilibrium, and just as a weight can do no work so long as it is kept suspended by an equal force, so no device, whether mechanical or chemical, can get any work out of the heat which a body contains so long as it is surrounded by matter of equal temperature. The heat contained in the melted iron of a blast furnace may be converted into work if the iron is taken out of the furnace, but so long as it remains there it can do no more work than can the heat contained in the material of an iceberg. In short, no matter what forces may act upon a body, whether mechanical or chemical or electrical in their character, there can be no work performed so long as the forces are held in equilibrium. The tension produced may be very great, but no work is possible. Any attempt to utilize the natural heat of the water of the ocean for performing work is of precisely the same character as an attempt to utilize its weight for a like purpose.

The subject is, perhaps, a hackneyed one, but since men of considerable scientific ability are even now puzzling themselves over it, a glance at the fundamental error involved may not be out of place.

C. L. D.

THE INJECTOR.

In this discussion of the injector we will not go into the refinements of the problem, but confine ourselves *mainly to pointing out the leading principles.*

An injector is an instrument used principally for forcing water into a boiler. When we consider that steam leaving the boiler under a high pressure with a great velocity is condensed *en route* and re-enters the boiler as water at a greatly reduced volume the governing principle at once becomes evident.

Thus, if an opening of one square inch in area is made in a boiler carrying a pressure of 60 pounds per square inch (absolute pressure 75 pounds) the steam will issue, neglecting friction, with a velocity of 2620 feet per second and the volume of steam issuing

will be 18.3 cubic feet. The ratio of volume of steam, at 75 pounds per square inch absolute pressure, to volume of equal weight of distilled water is 355.5 to 1. Hence, if the steam is suddenly condensed to water it will maintain its velocity, but is reduced in volume from 18.3 cubic feet to .0515 cubic feet, or in other words, the jet of steam of one square inch in area which issued from the boiler at a velocity of 2620 feet per second would be reduced to a jet of water 1–16 inch in diameter retaining the velocity of the steam.

Now, under a pressure of 66 pounds per square inch, that is, under a head of 138.4 feet, the water will have a velocity of 94.3 feet per second, and any stream having a velocity greater than 94.3 feet per second if directed against an orifice in the vessel, and brought to rest in one second, will enter it. The jet of condensed steam 1–16 inch in diameter has a velocity of 2620 feet per second, or more than twenty-eight times that necessary to re-enter the boiler. Roughly speaking, the force imparting velocity to the steam is all that is available for forcing the feed water into the boiler; or in other words, twenty-eight times the weight of steam represents the amount of water (*i. e.*, feed and condensed steam) that can be forced into the boiler under the most favorable conditions, with the data assumed above. Of course, this amount is greatly reduced in practice by the friction in the discharge and receiving orifices, and in the pipes and bends, together with that due to the lift of the feed water, the height of water in the boiler above the delivery pipe, the losses by impact, radiation, conduction, etc.

If the supply of water is reduced, the entering stream becomes hotter and hotter, until a temperature is reached at which the steam is not all condensed and the injector ceases to work.

THE DUTY OF AN INJECTOR.

Taking the "Universal Locomotive Injector" No. 9, and assuming the boiler evaporation at 8 pounds of steam per pound of coal, we have expermentally

Pressure of Steam per sq. inch.	Max. Delivery in cubic feet per hour.	Temperature.	
		Feed Water.	Delivered Water.
125 pounds.	367.	66° F.	149° F.

The number of units of heat imparted to each pound of water delivered by the injector is 149°—66° = 83°. Taking the weight

of a cubic foot of water at a temperature of 66° F. as 62.3 pounds, we have the total weight of water delivered per hour = 367 × 62.3 = 22 937.5, so that the total amount of heat imparted to the water per hour is 22 937.5 × 83 = 1 903 813 units. The total heat of evaporation above 32° F. at a pressure of 125 pounds per square inch is 1189.6 units, and the heat remaining in one pound of steam above 32° F. after condensation is 149—32 = 117 units; so that each pound of dry steam gives 1189.6 — 117 = 1072.6 units of heat to the feed water; hence the weight of dry steam per hour is $\frac{1903813}{1072.6}$ = 1775 pounds. The number of foot-pounds of work performed per hour by the injector equals maximum delivery in cubic feet per hour × pressure per square inch × 144 = 367 × 125 × 144 = 6606 000. The weight of coal required to do this with the assumed boiler evaporation will be $\frac{1175}{8}$ =222 pounds; hence the duty of this injector per 100 pounds of coal is $\frac{6606000 \times 100}{222.}$ = 2 975 676 foot-pounds. This result is still further established by a carefully conducted experiment between an injector and pump at the coal mine Idunna, Bachum, Germany; where the water was delivered to a height of 64 feet. In this experiment the piston pump was operated from a shaft driven by a steam engine. It was found that the injector used 7.9 times as much steam as the pump, which conclusively shows that the injector considered as a purely pumping device is not economical.

ITS EFFICIENCY AS A BOILER FEEDER COMPARED WITH A STEAM PUMP.

In this experiment the feed water was taken from one tank and forced into another, the discharge outlet was throttled so as to obtain a counter-pressure equal to the steam pressure. The weight and temperature of the feed water was noted, also the increased weight and temperature of water discharged. The following are the results obtained:

No. of Exp.	Weight of Feed Water in lbs.	Temp. of Feed Water.	Steam or Counter Pressure lbs per sq. in.	Weight of Condensed Steam.	Final Temp. of Mixture.
1	357.25	50.5° F.	65	37.5 lbs	157° F.
2	332.5	51.0° "	67	34.0 "	157° "
Average.	345	50.75° F.	66	35.75 lbs	157° F.

With the steam pump the amount of feed water was weighed, the water outlet was throttled so as to obtain a counter-pressure equal to the steam pressure. The exhaust steam was discharged into a body of water of known weight and after mixture the total weight was found and the weight of steam expended in the test was obtained. The following are the results:

No. of Exp.	Weight of Feed Water.	Steam or Counter Pressure in lbs. per sq. inch.	Weight of Steam Used.
1	295 lbs.	63.5	7.5 lbs.
2	317 "	68.5	8.5 "
Average	306 lbs.	66	8 lbs.

For compression we will reduce all steam to feed water at a temperature of 157° F. and 66 pounds gauge pressure. Here the forcing of 345 pounds of feed water against a counter-pressure equal to the steam pressure required 35.75 pounds of steam; or 10.4 pounds of steam for every 100 pounds of feed water. In the pump the forcing of 306 pounds of feed water (at a temperature of 51° F.) against a pressure of 66 pounds per square inch required 8 pounds of steam. The heat units imparted to 8 pounds of steam from 51° F. to a boiler pressure of 66 pounds per square inch $= 8 \times [1177 - (51 - 32)] = 9264$. The number of heat units imparted to one pound of steam, from a temperature of 157° F. to a boiler pressure of 66 pounds per square inch is $1177 - (157 - 32) = 1052$; hence the number of pounds of steam required to force 306 pounds of feed water at 157° F. into the boiler at 66 pounds per square inch $= 9264 \div 1052 = 8.81$. Now the steam in the boiler must heat the feed water from 51° F. to 157° F. or impart 106° to each pound of feed water; so the total number of heat units imparted to feed water $= 306 \times 106 = 32436$. This gives us the total number of pounds of steam required to heat the feed water from 51° F. to 157° F., $32436 \div 1052 = 30.8$; hence the total number of pounds of steam used $= 8.81 + 30.8 = 39.6$, or it required

For pump, 12.9 lbs of steam for every 100 lbs of feed water.
For injector, 10.4 " " " " " " " " " "

It will be observed that the efficiency of the steam pump used in this experiment was low. A general rule, which is sustained by theory as well as by practice, is that the quantity of steam used by an injector is the same as that used by a well constructed pump doing the same work; *i. e.*, boiler feeding.

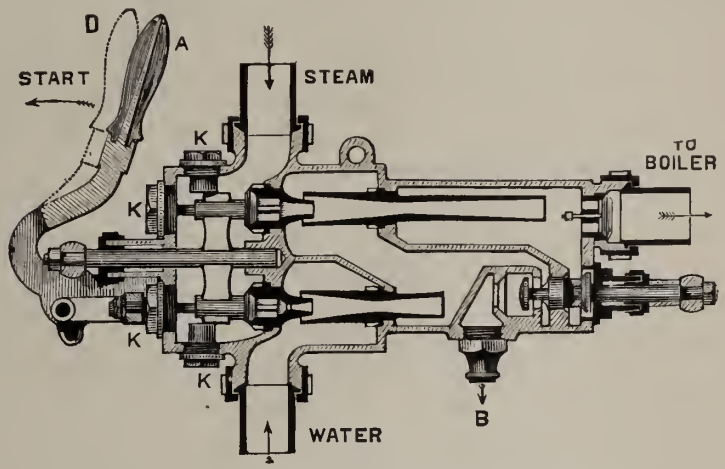
Recognizing the very important fact that the feed water should be introduced into the boiler at as high a temperature as possible, both with the view of maintaining an even temperature throughout the boiler—reducing the wear and tear arising from unequal expansion and contraction—and of effecting a direct saving in fuel, the question arises whether an exhaust heater would be an economical addition to the pump. It may or it may not. The only way in which we could test this point would be to take an indicator card from the engine when exhausting into the atmosphere, and again when exhausting through the heater. The difference between the back pressure lines will be the amount that is directly chargeable to the heater. As a locomotive boiler feeder the injector is fast coming into use, not in connection with the ordinary force pump, but taking its place. The effect of heavy reciprocating parts on a high speed engine, which includes the locomotive, is too well known to repeat here. On the locomotive we have not only the weight of the ordinary parts (the piston, piston-rod, cross-head and one-third of the connecting-rod), but the additional weight of a clumsy and awkward pump forcing cold water into the boiler, which was very good in its day, but should now be regarded as a useless and expensive appendage to a locomotive.

Although it is not possible to save fuel in using an injector, it nevertheless possesses important advantages. The apparatus can be attached to the boiler in any position independently of the engine. The construction is not costly and repairs are very small. The mechanism of the steam engine is simplified by the removal of the pumps. The feeding of the boiler can take place at a steam pressure lower than that required to start the engine. For locomotive boilers the injector, as it is independent of the engine, can take the place of all other pumps. A host of disturbances caused by freezing or injury to the pumps are wholly avoided. Moreover the continuous feeding with warm water saves the boiler; leakage from pipes is diminished, and the steam pressure is easly maintained. On ship-board the injector saves valuable space when used as a boiler feeder.

The best known form of a locomotive and stationary boiler injector, with which the writer is acquainted is the "Korting Universal Double-tube Injector." A sectional view of the same is shown by the accompanying cut.

The manipulation of the injector is simple; its action, positive.

It works to the same advantage and fulfills the same duty under all circumstances,—with high or low pressure steam, hot or cold water, under pressure or suction. As will be observed, the injector is a combination of two steam jets. The first one is proportioned for lifting and delivering the water under some pressure into the second one, where its velocity is sufficiently augmented to overcome the boiler pressure. It works at the lowest as well



as the highest steam pressure without any adjustment of parts, from the fact, that the quantity of water taken in by the lifting tube, and delivered to the forcing tube, is directly proportioned to the pressure of the steam. The first one thus acts as a governor to the second. This combination of the lifting and delivering tubes, the self-governing qualities, and its being without moving parts, greatly diminish its sensitiveness—an important point when the jarring motion of a locomotive is considered.

THOMAS M. EYNON, JR., M. E.

THE BETHLEHEM WATER WORKS.

The Water Works of Bethlehem are especially noted as being the first of the kind erected in America. They were originally designed and constructed by a Danish Moravian, Hans Christianson by name, a shoemaker by trade, but a mechanic by nature. On the twenty-first of January, 1764, these works were first put

in operation. and the custom of delivering the water supply in buckets was abolished. The pumping process consisted of three single acting force pumps, made of lignum vitæ, worked by means of a triple crank, geared to the shaft of an undershot water wheel eighteen feet in diameter.

In 1832 these works were entirely remodeled, and the double acting force pump, invented by Fred. Gauff, was erected. The Monocacy Creek was the motive power when the earliest works were constructed, and with very little modification the old pump is worked to-day as it was fifty years ago.

On the 4th of July, 1873, the pump in use at the present day was erected. It is a double acting "Cameron steam pump," and is capable of forcing about four hundred gallons per minute into the mains. Besides this the original force pump is still in use, and forces about seventy-five gallons per minute into the mains, so that ordinarily the maximum quantity of water that can be delivered is about four hundred and seventy gallons per minute, an amount wholly inadequate to meet the wants of a town of eight thousand inhabitants. In order to increase this supply a "Worthington steam pump" is about to be erected, and the sizes of the mains are to be increased throughout.

The original main was of gum wood, as far as the pressure was great, but the remainder was of pitch pine. The water was forced through these mains up into a receiver or small reservoir in the "High Tower," at the west end of the "Brothers' and Sisters' House." It was then, by the force of gravity, carried into water boxes and drawn off from them as needed.

The first pipes laid for the conveyance of water were of leather, but these proving unserviceable, wooden ones were soon substituted. In 1786, lead pipes replaced these, and in 1813 these were in turn changed for cast iron pipes, of the same style as those used at present.

At the time when the present system was introduced a reservoir, or cast iron stand pipe, eight feet in depth, with a capacity of 75,000 gallons was erected on the highest point in the town. The distance through which the water has to be forced—fully half a mile—causes an immense amount of expense and waste of energy. The entire head of the water is about one hundred and fifty feet. The spring, from which the supply of water is obtained, is situated at some distance from the works. Despite the fact, that the water is constantly being used, there seems to be

no diminution in the quantity. The water is clear and cool, perfectly healthful, very palatable, and withal as delicious a drinking water as can be found anywhere else in the State. Owing to the fact that it is rather a hard water, there being about twelve grains of lime to the gallon, it is scarcely fit for use for household purposes, and therein lies the chief objection to its use. This spring is liable to disappear at any day, owing to strata of rotten limestone which underlie the entire town. To partially obviate any evil which may arise, the pumps can be connected with the Monocacy. It cannot well be entirely rectified in this manner, for the water from this creek is scarcely fit for use, as it is always exceedingly muddy, and more or less polluted by organic matter. Perhaps many years hence the supply will be obtained from some other source, probably the Lehigh river.

J. H. W.

THE COMPOUND BLOWING ENGINE AT THE BETHLEHEM IRON COMPANY'S WORKS.

This engine, designed by the superintendent, Mr. Fritz, was built and erected by the Iron Company during the summer of 1884.

It is a compound direct acting engine of over 700 H. P., but is seldom run to its full capacity. It supplies blast to the Iron Company's furnaces. The stroke is 80 inches; diameter of low pressure cylinder, 54 inches; diameter of high pressure cylinder, 30 inches; diameter of blowing cylinder, 84 inches. The engine makes from 15 to 28 revolutions per minute. The pressure of the blast is from 9 lbs. to 16 lbs. per square inch; average, 11 lbs. per square inch.

There are no slide-valves, the entrance and exhaust of the steam being regulated by cam gear. A long iron rod, midway between the two steam cylinders and about three feet above them, is revolved about its axis by means of gear wheels connecting with the fly-wheel shaft. On this rod is a projecting piece of metal, so arranged as to press down a lever during a portion of the revolution. To this lever the valve is attached, and by varying the width and position of the projecting part on the rod the entrance and exhaust of the steam can be varied. There is a valve at each end of the steam cylinders. Steam is admitted at

the beginning, and cut off at 5–6 stroke. As this is a condensing engine, there can be no compression of exhaust. The condenser is below the engine; it is made of cast iron, and is cylindrical in shape. The steam enters near the bottom and is condensed by cold water trickling down from the top. The water is pumped out from below by means of a bell crank lever attached to the end of the cross-head. There are two of these levers, one on each end of the cross-head. One is used to pump the water from the condenser, while the other pumps a portion of this water into the boilers.

Steam enters at the middle of the steam chest of the high pressure cylinder, and exhausts at each end of this cylinder into passages leading to the middle of steam chest of the low pressure cylinder. From each end of this cylinder it is conducted to the condenser below. The steam cylinders and steam chests (as also the blowing cylinder) are covered with a wooden lagging to prevent the radiation of heat. The cross-head weighs about three tons. To each end one of the steam piston-rods is attached, and at the middle, but on the opposite side, the blowing cylinder piston-rod is fastened. The diameter of the piston-rod for the low pressure cylinder is 5½ inches; for the high pressure cylinder, 5 inches; for the blowing cylinder, 6 inches. The cross-head has a bearing surface at each end 24 x 33½ inches (= 804 square inches), making the total bearing surface 1608 square inches. Beyond the blowing cylinder is the fly-wheel shaft, 20 inches in diameter, having a fly-wheel at each end. Each wheel, weighing about 35 tons, is made of iron, cast in twelve segments, and is 23 feet in diameter. The connecting-rods from the cross-head to the fly-wheels are 17½ feet long, and are attached to the wheels at a distance of 42 inches from their respective centers.

From rough diagrams the average pressure per square inch on the piston of each steam cylinder was found approximately. That on the piston of the high pressure cylinder was 35.8 pounds per square inch, and that on the piston of the low pressure cylinder was 28 pounds per square inch. To find the indicated H. P. from these data, the engine making 20 revolutions per minute, we proceed as follows:

$$\text{H. P.} = \frac{\text{Av. pres. on piston per sq. in.} \times \text{area of piston in sq. in.} \times \text{vel. of piston in ft. per min.}}{33\,000}$$

At 20 revolutions per minute and 6⅔ foot stroke, the velocity in feet per minute = 20 × 2 × 6⅔ = 666⅔. The area of the high pressure piston is 706.5 square inches, and of the low pressure piston 2290 square inches. Hence

$$\text{H. P.} = \frac{(706.5 \times 35.8 + 2990 \times 28) \times 266\frac{2}{3}}{33\,000} = 722.$$

As this is a direct acting engine, we can readily see that the pressure on the slide bars is very small. To get an idea of this we assume that it comes from two sources, 1. the weight of the cross-head, 2. the pressure caused by the angularity of the connecting rods. The weight of the cross-head is 6,000 pounds. To find the second pressure we proceed as follows:

The average pressure on the two steam pistons = 89 384 lbs.
The average pressure on the blowing piston = 55 390 "

The difference, which is transmitted to fly-wheel = 33 994 lbs.

The pressure on the slide bars = $\frac{\text{total pres. transmitted} \times \text{radius of crank in inches}}{\text{length of connecting-rod in inches}} = \frac{33\,994 \times 42}{210} = 6\,800$ lbs. The sum of the two pressures is 12 800 pounds, and this divided by 1608 (total bearing surface of cross-head in square inches) = 8 pounds, which is the pressure per square inch on the slide bars. As a pressure of 40 pounds per square inch is allowable, we see that this pressure is very small, and the bars will last a long time.

This engine is very neat in appearance, simple in construction, and answers very well the purpose for which it was designed.

E. S. Stackhouse.

THE PAYNE HIGH SPEED ENGINE IN THE ELECTRICAL LABORATORY.

In the Payne engine the special features are the governor and the high speed. The governor belongs to that class in which the relative position of the eccentric is determined by the centrifugal force of weights revolving with the main shaft. A slight increase of speed is necessary to make the weights fly out. The amount of this necessary variation of speed depends greatly on the weight or velocity of the fly-wheel; since with a light fly-

wheel the variation of the load affects the governor so quickly that if it is at all sensitive it will fly from one extreme to the other and thus produce a still greater disturbance. But with a heavy fly-wheel, or what amounts to the same thing, one revolving at a high speed we can have a sensitive governor, and hence a uniform speed. This is one of the advantages of a high speed engine.

The engine under consideration has a cylinder 7″ in diameter and an 8″ stroke. The connecting rod is 24″ long, or in the ratio 6 : 1 to the crank. The steam ports are 5/8″ wide. The valve has 17–32″ outside lap and 1/8″ inside lap. In one extreme the eccentric has an angular advance of 120.°7, an eccentricity of 1 5–32″, and a lead of 1–16″; in the other it has an angular advance of 180°, an eccentricity of 35–64″ and a lead of 1–64″. The arm to which the eccentric is attached is pivoted opposite the crank so that the effect on the valve is the same as that of Stephenson's link motion with crossed arms.

By means of Zeuner's diagram and the above data I find the following results:

Distance in inches from end of cylinder.					
	Cut off	1	2	4	6½
	Exhaust opens	6¼	6½	7¼	7⅝
	Exhaust closes	4¼	5	6¼	7⅛
	Lead	1/64	1/64	1/32	1/16

I could not procure any actual indicator cards from the engine, so I assumed them from the above data, taking the initial pressure equal to 50 lbs., which is about the pressure available in the present case, although the engine was intended to run under a pressure of 60 lbs. The card assumed for cut off at ¼ stroke gives the following pressure per square inch of piston:

Part of stroke	0	.05	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95	1.00
Pres. in cylinder above atmosph.	50	50	50	50	43	30	24	20	17	14	10	6	3
Back pressure and compres.	3	0	0	0	0	0	0	0	0	5	13	20	30
Effectual pres.	47	50	50	50	43	30	24	20	17	9	—3	—14	—27

Average pressure 24 lbs.

The weight of the reciprocating parts is 104 lbs.; and I find that at 250 revolutions per minute, which is the speed intended for the engine, the pressure per square inch of piston required to

start these parts equals 48.89 lbs., or say 49 lbs., so that nearly or quite all of the pressure is used in starting the parts; and, taking into account the back pressure likely to exist at the beginning of the return stroke, there may even be a drag on the crank pin, which will cause it to pound. The pressure should therefore be increased to at least 60 lbs.

There is no reversal of pressure after beginning of stroke with above cut off, although this might easily happen with earlier cut off. The card for ¼ cut off gives the most uniform pressure on the crank pin, but with other points the pressure does not vary much. As ¼ is the normal cut off according to the statement of the makers, I will use the pressures given above in the further consideration of the tangential pressures and the fluctuations of the fly-wheel. The following tables give the actual pressures per square inch of piston transmitted to the crank pin, assuming the same diagram for both ends of the cylinder:

FORWARD STROKE.

Part of stroke	0	.05	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95	1.0
Pressure	—2	8	15	27	32	28	30	34	38	32	24	16	6

Average pressure = 24 lbs.

BACK STROKE.

Part of stroke	0	.05	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95	1.0
Pressure	12	17	19	24	24	16	18	23	33	36	36	33	20

Average pressure = 24 lbs.

By comparing these with the pressures shown by the card and tabulated above the modifying effect of the reciprocating parts is easily seen. These pressures converted into tangential pressures on the crank pin, taking into account the ratio of connecting rod to crank, are shown in the following tables:

FORWARD STROKE.

Part of stroke	0	.05	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95	1.0
Pressure	0	3.5	9.5	23	31	28	29.5	32	32	23	13	9.5	0

Average pressure = 20 lbs.

BACK STROKE.

Part of stroke	0	.05	.1	.2	.3	.4	.5	.6	.7	.8	.9	.95	1.0
Pressure	0	6.5	10.5	18	21	17	18	23	32	31	20	15.5	0

Average pressure = 19 lbs.

The average pressures are not alike because of the angularity of connecting rod with axis of cylinder. Nor are they equal to the average tangential pressure for the whole revolution as the radial lines in the diagram on which they were measured were not at equal angular distances apart. The average tangential pressure for the whole revolution equals 24 lbs. (the average pressure on crank pin per square inch of piston) multiplied by 0.636⅔ which equals 15¼ pounds per square inch of piston. The greatest excess of tangential pressure equals 12.45 pounds during the forward stroke, acting through ninety degrees.

The fly-wheel weighs 325 lbs. with a mean radius of 17″. The variation is found to be 1–332, which is very small; hence the the engine should run very steadily. The clearance on the crank end of cylinder is about ⅞″, while that on the other end is only about 1–16″.

With this exception the engine seems to be well designed and well constructed. CURTIS H. VEEDER.

THE ELECTRIC LIGHT IN BETHLEHEM.

The Bethlehem Electric Light Company was organized in November, 1883. Mr. Thomas of the firm of Davies & Thomas of Catasauqua is president; Geo. W. Walker, superintendent; and W. J. Alexander, electrician.

The plant is located in the southwestern part of Bethlehem, near the Lehigh Canal, and occupies a building 40x36 feet in the clear, two stories high, with a boiler house attached. The main building is built of brick, the walls of the lower story being 2 feet thick. The boiler house is 12x15 feet, with a stack 8 feet 6 inches square at the base and 65 feet high. In the boiler house are two flue boilers 14 feet long, 50 inches in diameter, having a total H. P. of 120 at 60 pounds pressure. The water to supply these boilers is pumped from the canal by a No. 2 Cameron pump.

In the main building are three Davies & Thomas vertical engines; two of 100 H. P. each, making 250 revolutions per minute, and one of 20 H. P., making 300 revolutions per minute. The intention is not to use all of these engines at the same time, but to keep one always ready in case anything should happen to one of the others.

The company has at present two Thompson & Houston dynamos, each making 950 revolutions per minute, and having a capacity of 38 lights; also 54 arc lights of the Thompson & Houston pattern with a power of 2,000 candles each.

To supply these lights four miles of No. 4, and five miles of No. 6 wire are used. E. O. S.

THE UNIVERSITY PARK.

The park is situated on the outskirts of South Bethlehem, near the foot of South Mountain. A few years ago it was enlarged by the addition of eight or ten acres of land lying to the east of the original site, giving to it its present area of forty acres and three rods. Its shape is that of an irregular polygon of nine sides, two sides, the northern and southern, being parallel. The eastern and western boundaries are irregular. The entire distance around the park is 83.40 chains, or over one mile. Two brooks run through it, one in the eastern, the other in the western part. The western one has its origin near the southern boundary; the eastern, which is much the larger, has its source near the top of the mountain, and has a deep bed, which is crossed at two points by the roads to the Athletic grounds.

The buildings, eleven in number, all facing the north, are arranged in the form of a semi-circle. The following are the principal ones: Packer Hall, the central building, contains the principal lecture and recitation rooms, drawing rooms, physical laboratories, and a Geological and Natural History museum. The building next in importance is the new Laboratory, fully described in another article. Then come the Library, Gymnasium, Observatory and Boiler house.

The natural slope of the surface is from 6½° to 7°, but in the front and the rear of most of the buildings is a terrace of much greater slope. From the tower of Packer Hall a fine view of the surrounding country can be obtained. Towards the north can be seen the Blue Mountains, while east and west the Lehigh River can be seen with long trains of coal cars running on both banks. To the east of the park are the grounds of the University Athletic Association, leveled from the side of the mountain, which are ap-

propriately fitted with a quarter-mile track, tennis courts, and accommodations for the foot ball, base ball, and lacrosse teams.

Within the last year the method of heating the buildings has been greatly improved. Formerly each building was heated by furnaces placed beneath it, but this was changed last year by the erection of the new boiler house, which is situated near the northeastern corner of the park. The steam is conducted through pipes laid in underground galleries of sufficient size to permit the passage of a man, so that repairs can be readily made.

F. W. Fink.

THE LABORATORY.

The plan of the new laboratory was designed by the distinguished architect Mr. Addison Hutton, of Philadelphia. The contract for its erection was given to Stacy, Reeves & Co., of the same city, who had it ready for occupation by September 1, 1884.

GENERAL DESCRIPTION.

The building is located in the southeastern part of University Park, on a line with Packer avenue. It consists of a central portion three stories in height besides a basement, thirty-seven feet front and fifty-seven feet deep; on each side of this center building wings extend east and west, each ninety feet long and forty-seven feet deep. These wings are two stories in height and have basements.

Another wing, two stories high, extends back from the center building ninety-five feet, and is fifty feet wide. Thus the entire frontage is two hundred and seventeen feet, and the greatest depth one hundred and forty-one feet. The walls, which are two and one-half feet thick, are built of Potsdam sandstone, and carry layers of ornamental brick between the stories. Fifty-six brick chimneys surmount the structure. The floor beams are of wrought iron, while communication between the different stories is had by means of cast-iron stair-cases rising in the central portion of the building. Dumb-waiters or lifts connect with all the floors. Speaking tubes afford easy means for communication throughout various parts of the building.

There are two main entrances; one opens into the basement of the central building from the north side; the other leads into the south wing from the west side. Besides these there is a private entrance into the west wing and an entrance to the offices of the professor in chemistry in the east wing.

THE CENTER BUILDING.

Entering the basement we pass through the vestibule into the main corridor, which branches out into a long side corridor almost wholly dividing the eastern wing basement into two equal parts. A packing room occupies the southwestern portion. The first story contains a recitation room, a lecture preparation room, and the corridor connecting with the first stories of the eastern and western wings respectively, and extending back over the first floor of the southern wing. The second story is divided up into the offices of the instructors in qualitative and quantitative analyses, respectively, the laboratory supply room, which extends back into the southern wing, and the corridor which communicates with the laboratories on the second floors of the eastern and western wings, and extends into the second story of the southern wing. The third floor is occupied by the Photographic Department, and consists of a laboratory and two dark rooms. The southwestern portion of this story is a room in which all the distilled water for the laboratories is made. Proper pipes conduct it to the different laboratories.

THE EASTERN WING.

The eastern portion of the basement is assigned to the Industrial Chemical Department. North of the corridor are two rooms for gas analysis, which are fully equipped with the necessary apparatus. The gas for analysis is made by the student. East of these rooms is the room for photometry, and a second room for industrial chemistry. A gas storage tank is next to this room. South of the corridor is the engine room. In this room is the pump running the blast in the various parts of the building and working the suction in the different laboratories. Another engine works the ore crusher connected with the Assaying Department. The rest of this basement comprises the toilet room opening into the center building. The first floor includes the two offices of the professor in chemistry, the lecture supply room extending across the entire width of the floor and the chemistry

lecture room. To the designing of this room all possible attention has been paid in regard to modern improvements. The chairs, numbering one-hundred and fifty-four are arranged in horizontal tiers rising one above the other. Experiments are conducted in full view of the entire class, on a table extending across the room. On the wall facing the class the drawings and diagrams necessarily accompanying each lecture are suspended. When the entire exclusion of all light is required, as during stereoptically illustrated lectures, a simple mechanical arrangement is had to draw every curtain simultaneously. The second floor is divdied into a room in which all the sulphureted hydrogen is generated, and the Qualitative Laboratory. Eighty-four students can here be accommodated at one time. Two rows of seven working tables each are arranged in the room. Each table contains ample drawer and locker room, and is covered with talc slabs, carrying bottle racks and gas-distributors. Sinks within easy reach are found in each window recess. Hoods for the evaporation of acids, etc., are fastened on the side walls at convenient distances. Flues opening into the hoods carry off all fumes that may arise. Steam is used to conduct the evaporation.

THE WEST WING.

The western portion of the basement is divided into three rooms—the room containing the balances, the silver bullion assay room, and a similar room for gold bullion assays. The remainder of this basement is intended for the assaying of different ores. Seven assay furnaces with semi-cylindrical muffles occupy the central part of the room. There are, besides, thirty-one furnaces, made of iron and lined with fire-bricks, and having heavy top-plates of iron for covers, which are intended for calcining, roasting, fusion, etc. Six working tables, accommodating thirty-six students, occupy a portion of the room. The assay supply room lies directly east of this room. The first floor consists of a room for organic chemistry, a room for balances, a laboratory for physiological chemistry, another for agricultural chemistry, and a chemical museum. The second floor comprises a room containing chemical books of reference, a balance room containing thirteen analytical balances resting on slate slabs, which are firmly fixed on pillars supported by the foundation walls, thus giving them a firm position. A sky-light admits light besides that entering from the sides of the room. Adjoining this is the room in

which combustions are conducted. It is provided with a blast lamp, an oxygen storage tank, aspirator, and combustion furnace. East of these rooms, and divided from them by a corridor, is the laboratory for quantitative analysis. There are twelve tables in the room. Each one accommodates four students, and is similar in construction to those found in the qualitative laboratory. These tables are provided with suction pipes, by means of which rapid filtering can be accomplished. The hoods and sinks are arranged as described in the other laboratory. There are, besides, drying hoods, air baths, etc.

THE SOUTH WING

is occupied by the Metallurgical Department. The southern portion of the first floor is divided into two rooms. One is the laboratory for class instruction in blow-pipe analysis, and in the practical work of determining crystals and minerals. The cabinets are ranged around the walls. West of this room is the Dry Laboratory, containing furnaces using gaseous or solid fuel. They are supplied with blast and with natural draught. On the east side of the dividing corridor is the laboratory for the wet analysis of ores, and a room for sanitary chemistry. On the west side is a room for packing purposes and another for instruments.

The second floor contains the mineralogical museums, occupying the southern portion, a lecture room and an Industrial Chemistry room lying east of the corridor, opposite the study of the professor of mineralogy and metallurgy.

WATER SUPPLY AND FIRE PROTECTION.

All parts of the building are abundantly supplied with water from pipes connecting with the water mains of the town. In the principal parts of the building pipes terminate with two-inch outlets, having sufficient lengths of hose attached ready for immediate use. Fire extinguishers and hand grenades, for extinguishing fires, are distributed throughout the entire building,

HEATING AND VENTILATION.

The most improved system of steam heating has been adopted. The steam is supplied from the boiler house and carried by means of pipes, well wrapped to prevent a loss of heat, to the different

rooms, where it passes into radiators capable of being regulated as desired.

The principal laboratories are twenty feet high, have numerous windows of the best approved pattern, and have large transoms over the doors opening into them. Registers along the floor-line of each room connect with the flues leading to the chimneys, thus causing all fumes, heavier than the air, to be drawn into these flues and carried away. It may safely be said that there is not another laboratory in this country as exempt from noxious gases and suffocating fumes as is this one.

The Lecture rooms are supplied with similar means for purifying the atmosphere and keeping it at proper temperatures.

R. S. Breinig.

About the first of March, workmen commenced driving the piles and erecting the staging preparatory to removing the old Howe Truss on the L. & S. branch of the C. R. R. of N. J. where it crosses the Lehigh Canal at Bethlehem. In place of the old bridge there now stands a single system Whipple Truss of the most improved pattern. The work was done by the Phœnix Bridge Company, they, of course, using their patent columns. It is a thorough bridge and is on a curve, necessitating a skew of nearly 22°. The panel lengths are so arranged as to divide the bridge into three distinct parts—the two end parts, of one panel length each, taking all of the skew and the middle part, of four panel lengths, being unaffected by the skew. While the new bridge was being put up, the floor system of the old one was supported upon piles, driven directly into the bed of the canal, thus there was no interruption of the traffic. There were no boats running at the time, the canal being frozen over, so the piles for the support of the staging, etc., could be driven wherever they were needed.

The new bridge is quite a contrast to the clumsy looking structure which it replaces. It is rumored that the R. R. Co., intends to replace the wooden bridge over the Lehigh River by an iron bridge similar to the one above described. P.

OBITUARY.

FREDERIC COPELAND WOOTTEN.

Frederic Copeland Wootten, the youngest son of Mr. John E. Wootten, General Manager of the Philadelphia & Reading Railroad, was born Nov. 18, 1858. In September, 1876, he entered Lehigh University, where he took the course in mechanical engineering, graduating in 1880. He was an intelligent and faithful student, who stood high in his class and showed both disposition and ability for original investigation and experiment. His graduating thesis, "On the best position for the center of gravity in locomotives," was a very interesting and suggestive argument to prove that a high position of the center of gravity rendered a locomotive less liable to oscillation than a low position, and was illustrated by several ingenious experiments made by himself on locomotives. After graduating he entered the shops of the Pennsylvania Railroad at Altoona, and about a year later was appointed to the position of assistant foreman of the locomotive department of the Pittsburgh division. His faithfulness and energy in the discharge of his duties were about to be rewarded by a promotion to a higher position, when in the fall of 1883 he was taken dangerously ill with Bright's disease of the kidneys. In January, 1884, he recovered so far as to be taken to his home in Reading, where he improved sufficiently to be able to walk upon the street and even to attend our commencement exercises in June. But in the fall a relapse occurred, and he died on November 16, 1884. He was a member of Christ (Episcopal) Cathedral in Reading, having been a member of its boy choir and Sunday-school, and was always a constant attendant upon its services when at home. In college he was universally liked and esteemed, on account of his quiet, modest, and manly disposition; he was the historian of his class, and always took an active part in promoting the best interests of the University. He was a member of the Engineers' Club of Philadelphia, whose *Proceedings* for 1884 contain an obituary notice, which pays a high tribute to his character and professional ability. He died two days before the completion of his twenty-sixth year. M. M.

SAMUEL BRENTON SICKLER.

Samuel Brenton Sickler, the only son of Hon. Harvey Sickler, of Tunkhannock, Pa., was born in 1859. In September, 1878, he entered Lehigh University, where he took the course in civil engineering, and graduated in 1882. As a student he was faithful and painstaking, particularly excelling in practical work, and during the last term of the senior year he stood at the head of his class. His graduating thesis, "On a plan for the water supply of Montrose, Pa.," was regarded as a very able production. He was one of the

promoters of the reorganization of this Engineering Society in 1881, and was elected its secretary for that year. After graduation he entered into the service of the Lehigh Valley Railroad Company and was employed in the office of Chief Engineer Steadman until the spring of 1883, when he was assigned to duty as Assistant Engineer on the construction of the Vosburg tunnel. He was careful and painstaking in his work, and was frequently complimented for the skill and accuracy with which he conducted the alignment of the tunnel. On the afternoon of December 4, 1884, he started to come out of the tunnel, and having reached a place near the east end where they were working a "bench," he stopped to inquire the best way to climb down, when a mass of rock fell upon him from the roof and horribly crushed him. Physicians were immediately summoned, but their efforts were of no avail, and he died a few hours later. The funeral took place on Sunday, December 7, when, with the impressive services of the Episcopal Church and of the Knights Templar, his body was consigned to the grave. In college he was a general favorite, where his gentle, genial qualities of heart and mind rendered him beloved and esteemed by all. Said the *Pittston Gazette:* "He was singularly well-endowed with all the qualities, moral, mental, and social, that go to make up a well-rounded, wholesome, genial and refined character; he was a favorite in Tunkhannock, and the pride not only of his parents but of the town, and his sudden and shocking death sends mourning into every household that knew him." He was aged twenty-five years and four months. M. M.

THE ENGINEERING SOCIETY of The Lehigh University, which is composed of the seniors and juniors of the engineering schools of the University, proposes to publish its JOURNAL quarterly during the college year. The majority of the articles in this initial number are written by the under-graduates, but vital assistance has been received from graduates and professors. The knowledge and views of the undergraduates are of necessity narrow, and if the matter for publication is entirely supplied by them, THE JOURNAL will lack that scope and completeness which is the essence of a successful engineering periodical. We therefore appeal to the alumni, to each of whom a copy of this number will be sent, for assistance in the shape of contributions either of complete articles or of information respecting the whereabouts and doings of themselves or their fellow alumni. It has been charged that the alumni of Lehigh are indifferent to the success of affairs connected with their Alma Mater if it involves any effort on their part. It is hoped that the response to this appeal will be of such a character as to effectually disprove the charge. Any information of however trivial a character it may seem to the sender will be gratefully received.

In each number we hope to present one or more articles written by the different professors of the University, which will add materially to the interest and value of the publication.

Subscriptions, the price of which has been placed exceedingly low, should be sent to THE SECRETARY OF THE ENGINEERING SOCIETY, LEHIGH UNIVERSITY, SOUTH BETHLEHEM, PA.

PROFESSOR DOOLITTLE'S treatise on Practical Astronomy, which is designed both as a text-book and a field manual, is in press. It will be published by Wiley & Sons, New York.

PROFESSOR MERRIMAN'S text-book on the Mechanics of Materials and of Beams, Columns and Shafts has been published by Wiley & Sons. An advertisement appears in another column.

THE translation of the great work of Weisbach on the Mechanics of Engineering should be largely credited to Lehigh University. In 1869, Eckley B. Coxe, one of our trustees, translated the first part. In 1877 Professor Dubois, who was then one of the faculty, translated the second part, which was issued in two volumes. In 1883, the first volume of Professor Klein's translation of the third part was published, and the second volume will probably appear about the end of the present year. The third part alone, as revised by Hermann, will form four or five volumes.

ALUMNI NOTES.

1869.

—Miles Rock, chief of the Boundary Commission of Guatemala, was the delegate from that country to the International Longitude Conference which met in Washington last November.

1870.

—Dr. John M. Thome has been appointed Director of the Observatory at Cordoba, Argentine Republic, vice Dr. B. A. Gould, who has resigned and returned to this country. At the recent dinner in Boston Dr. Gould spoke in the highest terms of the valuable services of Dr. Thome, who has been connected with the enterprise for fifteen years, and stated that he had begun a new and important astronomical work which will do honor to him and to the institution.

1872.

—D. P. Bruner is the General Manager for the Durham House Drainage Co., in Philadelphia, having his office in the Ledger building.

1875.

—A. E. Meaker has purchased a farm of 12 acres about half a mile west of Old South Bethlehem, upon which he has erected a handsome cottage.

1880.

—F. P. Spalding was married on June 22 to Miss Annie Packer Wilbur, of Bethlehem. Spalding's address is 280 Main Street, Memphis, Tenn., where he has established an office as civil engineer and contractor.

1882.

—C. C. Hopkins was married May 7 to Miss Eleanora Sherwood, at Woodhull, N. Y. Hopkins is now engaged on the construction of reservoirs for the water supply of Rome, N. Y.

—L. O. Emmerich and E. H. Lawall are both at Audenried, Pa., the former as resident engineer for the Wilkes-Barre Coal Co., and the latter as resident engineer for the Beaver Brook Estate.

—E. Ricksecker was at Carson City, Nevada, last winter, making a survey of a locality where cinnabar was being deposited by chemical action. This is the only known place where the formation of cinnabar is actually going on.

1883.

—G. S. Patterson is now engaged as mining engineer for Markle & Co., with headquarters at Jeddo, Pa.

—In the next issue we expect to give an article by N. O. Goldsmith, of the Weir Switch Co., Cincinnati, on double curved crossings.

—Mr. George Francis Duck has accepted the position of chemist to the Cherokee Iron Company at Cedartown, Georgia, and will enter upon his duties there about the 15th of June.

—W. T. Goodnow and T. B. Brown have opened an engineering office in Broadhead's new building, Bethlehem, and are engaged in land and city surveying, water supply and sanitary engineering.

1884.

—The address of William Langston is now 552 Lafayette Street, Brooklyn, N. Y.

—R. P. Linderman was elected one of the directors of the Lehigh Valley National Bank at the meeting of the stockholders in January.

—R. W. Walker is engaged on the party which is running the boundary line between Guatemala and Mexico. It is rumored that his salary is a high one.

—A. P. Smith is no longer connected with *Engineering News*, but is working for other papers in New York. His address is 204 Columbia Heights, Brooklyn, N. Y.

—J. F. Merkle was one of the engineers affected by the recent wholesale reduction of working force on the Philadelphia & Reading Railroad. His address is now Cressona, Pa.

JOHN WILEY & SONS,

15 ASTOR PLACE, NEW YORK,

HAVE JUST PUBLISHED

A TEXT-BOOK on the MECHANICS OF MATERIALS, and of Beams, Columns, and Shafts. By Mansfield Merriman, Professor of Civil Engineering in Lehigh University.

OCTAVO, CLOTH, 160 PAGES, 52 CUTS, PRICE, $2.00.

Messrs. Wiley also publish the following books by the same author:

THE FIGURE OF THE EARTH; an Introduction to Geodesy, 12mo, Cloth, $1.25.

A TEXT-BOOK ON THE METHOD OF LEAST SQUARES. Octavo, Cloth, $2.00.

*** Copies sent free by mail on receipt of the price by the publishers, or by E. G. Klose, Manager, Bookseller, Bethlehem, Pa.

ESTABLISHED 1847.

JAMES P. TOLMAN & SON

MANUFACTURERS OF

GOLD LEAF.

PARTICULARLY ADAPTED FOR CAR AND SHIP GILDING.

No. 627 FILBERT STREET,

PHILADELPHIA, PA.

WHY NOT——————TRY THEM?

L. SCHUTTE & CO.,

TWELFTH AND THOMPSON STREETS,
PHILADELPHIA, PA.

ENGINEERS AND MACHINISTS, CONTRACTORS FOR HYDRAULIC AND SPECIAL MACHINERY.

SOLE MANUFACTURERS AND OWNERS OF PATENTS OF THE

UNIVERSAL INJECTOR,

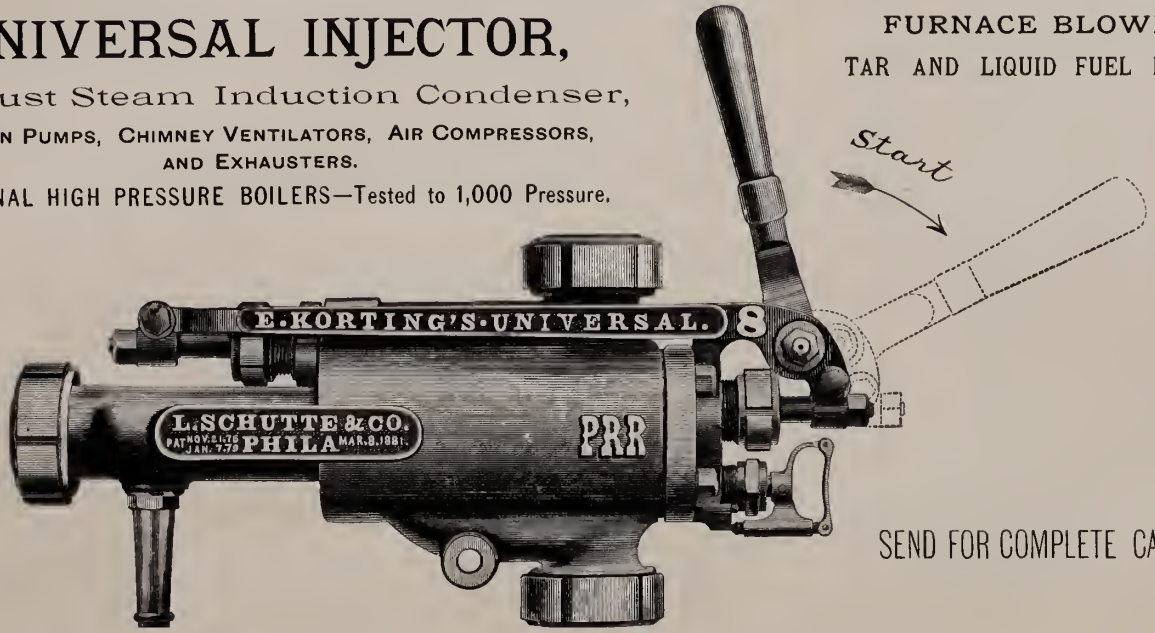
Exhaust Steam Induction Condenser,

SYPHON PUMPS, CHIMNEY VENTILATORS, AIR COMPRESSORS, AND EXHAUSTERS.

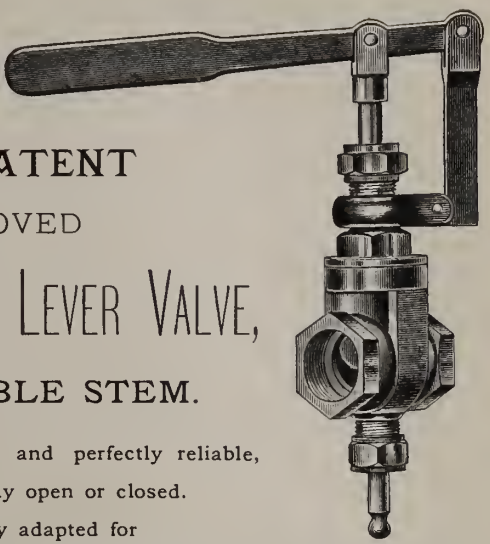
SECTIONAL HIGH PRESSURE BOILERS—Tested to 1,000 Pressure.

FURNACE BLOWERS,

TAR AND LIQUID FUEL BURNERS.



SEND FOR COMPLETE CATALOGUE.



ROSS' PATENT

IMPROVED

QUICK OPENING LEVER VALVE,

WITH DOUBLE STEM.

Adapted to all pressures and perfectly reliable, whether full or partly open or closed.

It is particularly adapted for

Hoisting Engines and all Engines

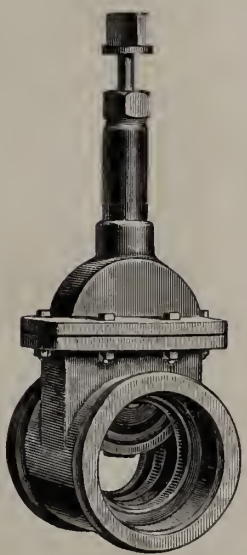
WHERE QUICK OPENING VALVES ARE REQUIRED.

MANUFACTURED ONLY BY

B. E. LEHMAN,

LEHIGH VALLEY BRASS WORKS,

SOUTH BETHLEHEM, PA.



ALSO

BRASS AND IRON WAY GATE VALVES FOR WATER, GAS, and STEAM.

Inquiries and orders by mail receive prompt attention.

THE LEHIGH UNIVERSITY,

SOUTH BETHLEHEM, PA.

FOUNDED BY ASA PACKER.

THE object of this Institution is to give a thorough education in Civil, Mechanical, and Mining Engineering, in Chemistry, Metallurgy, the Classics, and in General Literature.

Through the liberality of its Founder, the TUITION in all branches is FREE.

REQUIREMENTS FOR ADMISSION.

Applicants for admission must be at least sixteen years of age, and must present testimonials of good moral character.

For admission to the Courses in Science and Letters; Civil, Mechanical, and Mining Engineering; and Analytical Chemistry, the examinations are in the following subjects:

MATHEMATICS.

Arithmetic, complete, including the Metric system; Algebra, through equations of the second degree; Chauvenet's Geometry, six books.

ENGLISH.

Grammar; Geography; United States History, including the Constitution; Elementary Physics.

For admission to the Latin Scientific course, the examinations are in the foregoing, and in

LATIN.

Latin Grammar; Cæsar's Commentaries, four books; Virgil; Æneid, six books, and the Bucolics; Cicero: six Orations, including the four against Cataline; Latin Composition; Roman History.

For admission to the Classical Course, the examinations are in all the foregoing subjects, and in

GREEK.

Greek Grammar; Xenophon's Anabasis, four books; Homer's Iliad, three books; Writing Greek with Accents; Greek History.

The examinations will be rigorous, and no student deficient in any branch will be permitted to enter in full standing.

For further information apply to the President,

ROBERT A. LAMBERTON, LL.D.,
SOUTH BETHLEHEM, PA.

PREPARATORY SCHOOL

FOR

LEHIGH UNIVERSITY

WM. ULRICH, PRINCIPAL, BETHLEHEM, PA.

REFERENCES:

R. A. LAMBERTON, LL.D., President of Lehigh University, and any of the Professors belonging to the Faculty of Lehigh University.

IN this School attention is given exclusively to the requirements for admission to Lehigh University. Its course is finished when these have been thoroughly mastered. During the past five years over one hundred of our scholars have been admitted to the University in full standing.

SUMMER COURSE

In order to enable young men, not sufficiently prepared to pass the June Examination of Lehigh University successfully, to pursue the course of studies that will be necessary for them to enter the University in September, it is our custom to establish a Summer Course immediately after the June Examination. The Summer Course is also very recommendable to young men wishing to pass the Examination, June, 1886.

FOR CIRCULARS AND OTHER INFORMATION APPLY TO THE PRINCIPAL.

THE BOOKSTORES

No. 146 MAIN STREET, *BETHLEHEM, PA.*

No. 10 EAST THIRD STREET, *SOUTH BETHLEHEM, PA.*

THE HEADQUARTERS

For any article which may be required by the students at the University or the Preparatory Schools in the vicinity.
Special facilities for procuring anything not in stock, and at the lowest prices.

BOOK NEWS AND JOB PRINTING.

THE BEST EQUIPPED ESTABLISHMENT IN THE LEHIGH VALLEY FOR

FINE BOOK WORK

—AND—

ARTISTIC JOB PRINTING

At the lowest prices in accordance with superior quality of workmanship.

AS LATE SPECIMENS OF OUR WORK WE REFER TO "THE LEHIGH BURR," PROF. JOHNSON'S "PERSIUS," "THE EPITOME," AND "THE ENGINEERING JOURNAL."

EDWIN G. KLOSE, MANAGER.